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(54) Data recording method and apparatus.

(57) A method of and apparatus for recording data onto a disc-shaped recording medium having a sector construction such as an optical disc increases the interleave length of recorded data to cope with burst error or the like by dividing input data into predetermined lengths, respectively two-dimensionally arranging the divided data, generating and adding error correction codes to the two-dimensionally arranged data by a predetermined series to thereby form n encoded blocks; changing the data arrangement among the n encoded blocks; and distributing and recording the changed data to each sector on the disc-shaped recording medium.

Fig. 1

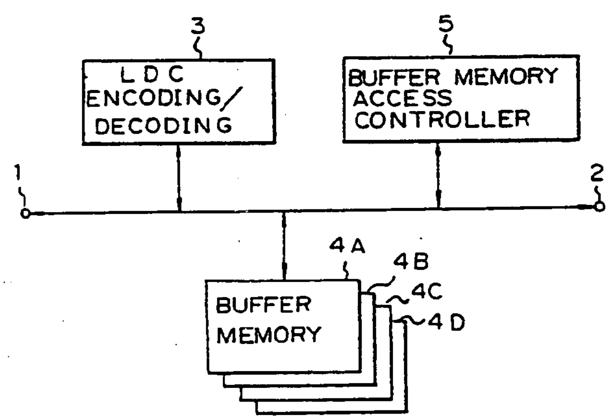
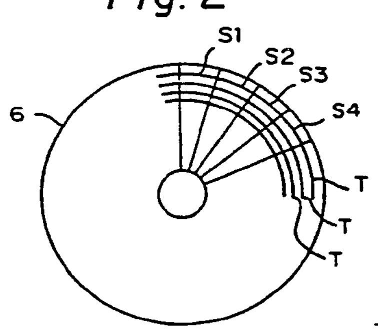


Fig. 2



EP 0 364 229 A2

DATA RECORDING METHOD & APPARATUS

The present invention relates to a data recording method which is suitable for use when data is recorded to, for instance, an optical disc and to apparatus for carrying out that method.

The development of the WORM (write once, read many) type optical disc and the erasable and rewritable optical disc (for instance, magneto optical disc) has progressed in recent times. In such an optical disc, each data track is divided into a plurality of sectors and data is recorded/reproduced on a sector unit basis. For instance, in the recording format for 5.25 inch diameter optical discs each data track is divided into 17 sectors into which data can be recorded.

In the conventional optical disc, in order to cope with burst errors or the like, the data for each sector is encoded with an error correction code and a parity code for error correction is generated and added.

For instance, among the recording formats of 5.25 inch optical discs, there is a format which uses an LDC (long distance code) as an error correcting method. In the recording format using the LDC, for instance, control data and a CRC code for error detection are added to each 512 bytes of the user's data, data is written into a buffer memory in the horizontal direction, error correction encoding is executed in which respective columns are used as an encoding series, and a parity code of 16 bytes per series (5 x 16 = 80 bytes per sector) is added. The data is read out from the buffer in the horizontal direction and recorded into the destination sector on the optical disc.

As mentioned above, in the case of generating and adding a parity for error correction of 16 bytes to one series, the error correction can be executed for up to eight bytes per series. Data is arranged into five columns, the error correction code is added by using each column as an encoding series, and the reading/writing operations are executed in the horizontal direction, so that an interleave of five bytes is executed. Therefore, in this case, it is possible to cope with the generation of burst errors of up to 5 x 8 = 40 bytes. Defects of 40 bytes extent correspond to a length of about 300 μm at the innermost rim of the disc.

As mentioned above, in the case of 5.25 inch optical discs, it is possible to cope with burst errors corresponding to for instance, 40 bytes by the LDC. However, in a recording medium such as an optical disc on which data is to be recorded at a high density, it can happen that fairly large burst errors are generated. In such a case, error correction cannot satisfactorily be executed by the LDC as mentioned above.

Therefore, when recording data onto an optical disc, a verification is made to see if errors equal to or exceeding a predetermined value have been generated in the sector into which data is to be recorded or not. The sector in which errors of a predetermined value or more are generated is regarded as a defective sector. The data to be recorded into the defective sector is then recorded into an alternate sector. In this manner, the alternate sector process as mentioned above is performed.

However, even if such an alternate sector process is executed, it is impossible to cope with large burst errors which are generated after data has been recorded. If large burst errors are generated in a read only disc, the alternate sector process cannot be executed.

It is, therefore, an object of the present invention to provide a data recording method which can effectively execute error correction of large burst errors.

Another object of the invention is to provide a data recording method which can improve the correcting capability for large burst errors without largely changing the required circuitry and format.

In according with the present invention, there is provided a method for recording data onto a disc-shaped recording medium having a sector construction, comprising the steps of:
dividing input data into predetermined lengths, respectively two-dimensionally arranging said divided data, generating and adding error correction codes to said two-dimensionally arranged data by a predetermined series, thereby forming n encoded blocks, where n is an integer;
changing the data arrangement among said n encoded blocks; and
distributing and recording said changed data to a sector on the disc-shaped recording medium.

The invention also provides apparatus for recording data onto a disc-shaped recording medium having a sector construction, comprising:
means for dividing input data into predetermined lengths;
means for respectively two-dimensionally arranging said divided data;
means for generating and adding error correction codes to said two-dimensionally arranged data by a predetermined series, thereby forming n encoded blocks, where n is an integer;
means for changing the data arrangement among said n encoded blocks; and
means for distributing and recording said changed data to a sector on the disc-shaped recording medium.

In this invention, the input data is stored into buffer memories and encoded by the LDC, respectively. The encoded data is controlled by a buffer memory access controller so that the interleave length becomes substantially long and is recorded into each sector on the disc. In the case where the input data is divided into, for instance, four encoding blocks and the data is rearranged among the four encoded blocks and is recorded, the interleave length is substantially increased four times as compared with that in the case where the data is not rearranged. Therefore, the error correcting capability for burst errors can be increased.

The invention will be further described by way of non-limitative example with reference to the accompanying drawings, in which:-

Figure 1 is a functional block diagram which is used in explanation of a preferred embodiment of the present invention;

Figure 2 is a plan view showing the data arrangement of a disc for use in the embodiment of the invention depicted in figure 1;

Figure 3 is a flowchart which is used in explanation of the encoding in the embodiment of the invention depicted in figure 1;

Figures 4A, 4B, 4C and 4D are schematic diagrams which are used in explanation of the encoding blocks in the embodiment of the invention depicted in figure 1;

Figures 5A, 5B, 5C and 5D are schematic diagrams which are used in explanation of the recording of data in each sector in the embodiment of the invention depicted in figure 1;

Figures 6A, 6C, 6C, 6D and 7A, 7B, 7C and 7D are schematic diagrams which are used in explanation of the embodiment of the invention depicted in figure 1;

Figure 8 is a flowchart which is used in explanation upon decoding in the embodiment of the invention depicted in figure 1; and

Figures 9A, 9B, 9C and 9D are schematic diagrams which are used in explanation of another embodiment of the invention.

A preferred embodiment of the present invention will be described hereinbelow with reference to the drawings.

In figure 1, reference numeral 1 denotes an input/output terminal for recording or reproduction data; 2 indicates an input/output terminal for data which is recorded or reproduced onto or from a disc 6 (figure 2); 3 an encoding/decoding circuit to perform the encoding and decoding of an LDC (long distance code); 4A to 4D buffer memories; and 5 a buffer memory access controller.

When data is recorded onto the disc 6, input data from the input/output terminal 1 is stored once in the buffer memories 4A to 4D. A parity for error correction is generated and added to the input data which was two-dimensionally arranged and stored in the buffer memories 4A to 4D by using each column as an encoding series by means of the encoding/decoding circuit 3.

When reproducing data from the disc 6, the reproduced data of the disc 6 is received at the input/output terminal 2 and is stored once in the buffer memories 4A to 4D. The error correcting process of the reproduction data of the disc 6 stored in the buffer memories 4A to 4D is executed by the encoding/decoding circuit 3.

The buffer memory access controller 5 controls the read or write addresses in the buffer memories 4A to 4D.

An erasable and rewritable optical disc, for instance, a magneto-optical disc can be used as the disc 6. As shown in figure 2, spiral or annular tracks T are formed on the disc 6. Each of the tracks T is divided into a plurality of physical sectors S_1, S_2, S_3, S_4, ... and data is recorded there.

The invention can be also similarly applied to a WORM type optical disc and to a read only optical disc. In addition, the invention can be also likewise applied to a magnetic disc such as a hard disc or the like.

First, the operation in the case of recording data onto the disc 6 will be described with reference to the flowchart shown in figure 3.

The data to be recorded onto the disc 6 is input at the input terminal 1. Input data of 512 bytes from data D_1 1 to D_1 512 is sequentially written into the buffer memory 4A in the horizontal direction. 512 bytes of subsequent data D_2 1 to D_2 512 is sequentially written into the buffer memory 4B in the horizontal direction. Subsequently, input data of 512 bytes, D_3 1 to D_3 512, is sequentially written into the buffer memory 4C in the horizontal direction. Lastly, 512 bytes of subsequent data D_4 1 to D_4 512 is sequentially written into the buffer memory 4D in the horizontal direction (step 11).

The data written into the buffer memories 4A to 4D is two-dimensionally arranged as shown in figures 4A to 4D.

That is, as shown in figure 4A, the data D_1 1 to D_1 512 are two-dimensionally arranged in the buffer memory 4A into four columns and 128 rows. A row of control data P_1 1 to P_1 4 and a row of CRC codes CRC_1 1 to CRC_1 4 for error detection are added to these data.

Similarly, as shown in figure 4B, the data D_2 1 to D_2 512 are two-dimensionally arranged in the buffer memory 4B in 128 rows and 4 columns. A row each of control data P_2 1 to P_2 4 and CRC codes CRC_2 1 to CRC_2 4 for error detection are added to these data.

In figure 4C, the data D_3 1 to D_3 512 are likewise two-dimensionally arranged in the buffer

memory 4C. The control data P_3 1 to P_3 4 and CRC codes CRC_3 1 to CRC_3 4 for error detection are added to these data.

Finally, as shown in figure 4D, the data D_4 1 to D_4 512 are two-dimensionally arranged in the buffer memory 4D. Control data P_4 1 to P_4 4 and CRC codes CRC_4 1 to CRC_4 4 for error detection are added to these data.

As shown in figures 4A to 4D, error correction codes are generated and added to the two dimensionally arranged data by the encoding/decoding circuit 3 by using each column as an encoding series (step 12 of figure 3).

That is, 16-byte parity codes E_1 1,1 to E_1 1,16, E_1 2,1 to E_1 2,16, E_1 3,1 to E_1 3,16 and E_1 4,1 to E_1 4,16 for error correction are generated and added to each of the respective columns of the encoding block shown in figure 4A.

Similarly, 16-byte parity codes E_2 1,1 to E_2 1,16, E_2 2,1 to E_2 2,16, E_2 3,1 to E_2 3,16, and E_2 4,1 to E_2 4,16 for error correction are generated and added to each of the respective columns of the encoding block shown in figure 4B.

Parity codes E_3 1,1 to E_3 1,16, E_3 2,1 to E_3 2,16, E_3 3,1 to E_3 3,16 and E_3 4,1 to E_3 4,16 for error correction of 16-bytes are generated and added to each of the respective columns of the encoding block shown in figure 4C.

Finally, 16-bytes parity codes E_4 1,1 to E_4 1,16, E_4 2,1 to E_4 2,16, E_4 3,1 to E_4 3,16 and E_4 4,1 to E_4 4,16 for error correction are generated and added to each of the respective columns of the encoding block shown in figure 4D.

As shown in figures 4A to 4D, by adding the 16 rows of parity codes for error correction to each column, error correction can be performed for up to eight bytes per individual series.

The data in the buffer memories 4A to 4D is read out under the control of the buffer memory access controller 5 and is output from the input/output terminal 2 and is recorded onto the disc 6. At this time, the reading operations of the buffer memories 4A to 4D are controlled by the buffer memory access controller 5 so that the interleave length becomes substantially long (step 13 of figure 3).

That is, for instance, when one data is read out of the buffer memory 4A, one data is then read out of the buffer memory 4B. Next, one data is read out of buffer memory 4C and one data is sequentially read out of the buffer memory 4D. By alternately reading out the data from the four buffer memories 4A to 4D as mentioned above, the sequence of the data is rearranged and the data is recorded in the physical sectors S_1 to S_4 on the disc 10 as shown in figures 5_A to 5E.

That is, as shown in figure 5A, the data is sequentially recorded into the physical sector S_1 in accordance with the sequence of the data D_1 1, D_2 1, D_3 1, D_4 1, D_1 2, D_2 2, D_3 2, D_4 2, . . . and so forth until the data D_1 146, D_2 146, D_3 146 and D_4 146 so that data comprising 584 bytes is recorded.

As shown in figure 5B, the data is sequentially recorded into the physical sector S_2 in accordance with the sequence of the data D_1 147, D_2 147, D_3 147, D_4 147, D_1 148, D_2 148, D_3 148, D_4 148, ... and so forth until the data D_1 292, D_2 292, D_3 292 and D_4 292 so that data comprising 584 bytes is recorded.

As shown in figure 5C, the data is sequentially recorded into the physical sector S_3 in accordance with the sequence of the data D_1 293, D_2 293, D_3 293, D_4 293, D_1 294, D_2 294, D_3 294, D_4 294, ... and so forth until the data D_1 438, D_2 438, D_3 438 and D_4 438 so that data comprising 584 bytes is recorded.

As shown in figure 5D, the data is sequentially recorded into the physical sector S_4 in accordance with the sequence of the data D_1 439, D_2 439, D_3 439, D_4 439, D_1 440, D_2 440, D_3 440, D_4 440, ... and so forth until the data E_1 4,16, E_2 4,16, E_3 4,16 and E_4 4,16 so that data comprising 584 bytes is recorded.

By recording the data onto the disc 6 by this rearranging method, the interleave length is substantially increased four times as compared with that in the case where the data is not rearranged.

That is, as shown in figures 4A to 4D, by arranging the data at four columns and adding parities for error correction of 16 bytes to every column, error correction of up to eight bytes per one series can be executed. In the case where the data is not rearranged, an interleave of four bytes is performed. Therefore, in the case where the data stored in the buffer memories 4A to 4D is recorded into the corresponding physical sectors on the disc 6 without rearranging the data, it is possible to cope with burst errors of only up to 8 x 4 = 32 bytes.

On the other hand, when the data ia rearranged and recorded onto the disc 6 as mentioned above, the interleave length is further increased four times. Therefore, it is possible to cope with burst errors of up to 4 x 32 = 128 bytes.

For instance, assume that defects occurred on the disc 6 in the data recording areas of 128 bytes, for example, in the data D_1 1 to D_4 32 in the physical sector S_1 1 shown as hatched portions in figure 6A. In this case, as shown by hatched portions in figures 7A to 7D, the errors are generated in the data of the first to eight rows in each encoding block. Since the error correction codes of 16 bytes have been added to each column in each of the encoding blocks of figures 7A to 7D, error correction of up to eight bytes in each encoding series can be executed. Thus, all of the errors

which were generated at that time can be corrected.

The operation during data reproduction will now be described. The operation upon reproduction is the inverse of that during recording.

That is, as shown in the flowchart of figure 8, the data from the physical sectors S_1 to S_4 on the disc 6 is sequentially reproduced. As mentioned above, the data has been rearranged and recorded in the physical sectors S_1 to S_4 on the disc 6.

This rearranged, reproduced data is input at the input/output terminal 2 and the sequence of the data is returned to the original sequence under the control of the buffer memory access controller 5 and the data is sequentially stored into the buffer memories 4A to 4D (step 21 of figure 8).

That is, the sequence of the reproduced data of the disc 6 based on the sequence as shown in figures 5A to 5D is rearranged under the control of the buffer memory access controller 5. The data D_1 1, D_1 2, D_1 3, D_1 4, ... is sequentially stored into the buffer memory 4A in the horizontal direction. The data D_2 1, D_2 2, D_2 3, D_2 4, . . . is sequentially stored into the buffer memory 4B in the horizontal direction. The data D_3 1, D_3 2, D_3 3, D_3 4, ... is sequentially stored into the buffer memory 4C in the horizontal direction. The data D_4 1, D_4 2, D_4 3, D_4 4, ... is sequentially stored into the buffer memory 4D in the horizontal direction. Thus, the reproduced data is returned to the original two-dimensional arrangement as shown in figures 4A to 4D.

For the data stored in the buffer memories 4A to 4D, the error correcting process is executed by the encoding/decoding circuit 3 by using each column as an encoding series. As mentioned above, the error correction can be executed for up to eight bytes by such an error correcting process by each encoding series. Therefore, it is possible to cope with burst errors of up to 128 bytes (step 22 of figure 8).

The data, once error correction processed, is sequentially read out of the buffer memories 4A to 4D and output from the input/output terminal 1 (step 23 of figure 8).

In the preferred embodiment, as shown in figures 5A to 5D, the data is rearranged in accordance with the sequence of the data D_1 1, D_2 1, D_3 1, D_4 1, D_1 2, D_2 2, D_3 2, D_4 2, ... However, the rearranging method of data is not limited to this manner. It is possible to use any rearranging method such that the interleave length becomes substantially long.

For instance, as shown in figures 9A to 9D, the data D_1 1, D_1 2, D_1 3 and D_1 4 of the first row in the encoding block in figure 4A is recorded into the physical sector S_1, the data D_1 5, D_1 6, D_1 7 and D_1 8 of the second row is recorded into the physical sector S_2, the data D_1 9, D_1 10, D_1 11 and D_1 12 of the third row is recorded into the physical sector S_3, and the data D_1 13, D_1 14, D_1 15 and D_1 16 of the fourth row is recorded into the physical sector S_4. It is possible to execute the rearrangement as mentioned above.

In the above embodiment, the input data is divided into four encoding blocks by the four buffer memories 4A to 4D and encoded and the data rearrangement is performed among the four encoding blocks. However, the number of encoding blocks is not limited to four. For instance, it is also possible to divide the input data into two encoding blocks and to execute the data rearrangement between the two encoding blocks. By executing the data rearrangement between the two encoding blocks as mentioned above, the interleave length can be substantially doubled. The number of encoding blocks into which the input data is divided is determined in consideration of the length of the burst errors which will be generated in the disc and the capacities of the buffer memories which can be realised. The information indicative of the number of encoding blocks which were divided can be written as a flag onto a control track or onto an ID section of each sector.

The invention is not limited to the LDC but can be also similarly applied to the case of using a product code.

According to the invention, the data which was divided into, for instance, four encoding blocks and encoded is recorded into each sector on the disc by rearranging the data sequence. By executing the data rearrangement among a plurality of encoding blocks, the interleave length becomes substantially long and the error correcting capability for burst errors can be increased.

Having described a specific preferred embodiment of the present invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to that precise embodiment, and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined in the appended claims.

Claims

1. A method for recording data onto a disc-shaped recording medium having a sector construction, comprising the steps of:
dividing input data into predetermined lengths, respectively two-dimensionally arranging said divided data, generating and adding error correction codes to said two-dimensionally arranged data by a predetermined series, thereby forming n encoded blocks, where n is an integer;
changing the data arrangement among said n en-

coded blocks; and
distributing and recording said changed data to a sector on the disc-shaped recording medium.

2. A data recording method according to claim 1 wherein said step of changing the data arrangement is performed in a manner such that plural data having the same coordinates are sequentially taken out from the two-dimensionally arranged data of said n encoded blocks and the data arrangement is changed.

3. A data recording method according to claim 1, wherein said step of changing the data arrangement is performed in a manner such that the plural data are sequentially taken out from the two-dimensionally arranged data of said n encoded blocks in the row direction and the data arrangement is changed.

4. Apparatus for recording data onto a disc-shaped recording medium having a sector construction, comprising:
means for dividing input data into predetermined lengths;
means for respectively two-dimensionally arranging said divided data;
means for generating and adding error correction codes to said two-dimensionally arranged data by a predetermined series, thereby forming n encoded blocks, where n is an integer;
means for changing the data arrangement among said n encoded blocks; and
means for distributing and recording said changed data to a sector on the disc-shaped recording medium.

5. Apparatus according to claim 4 wherein said means for changing the data arrangement operates in a manner such that plural data having the same coordinates are sequentially taken out from the two-dimensionally arranged data of said n encoded blocks and the data arrangement is changed.

6. Apparatus according to claim 4, wherein means for changing the data arrangement operates in a manner such that the plural data are sequentially taken out from the two-dimensionally arranged data of said n encoded blocks in the row direction and the data arrangement is changed.

7. Apparatus according to any one of claims 4 to 6 and including means for reading data from a designated sector of the disc, means for error-correction-processing the data and means for restoring the error-correction-processed data to its original arrangement prior to its two dimensional arrangement prior to recording.

Fig. 1

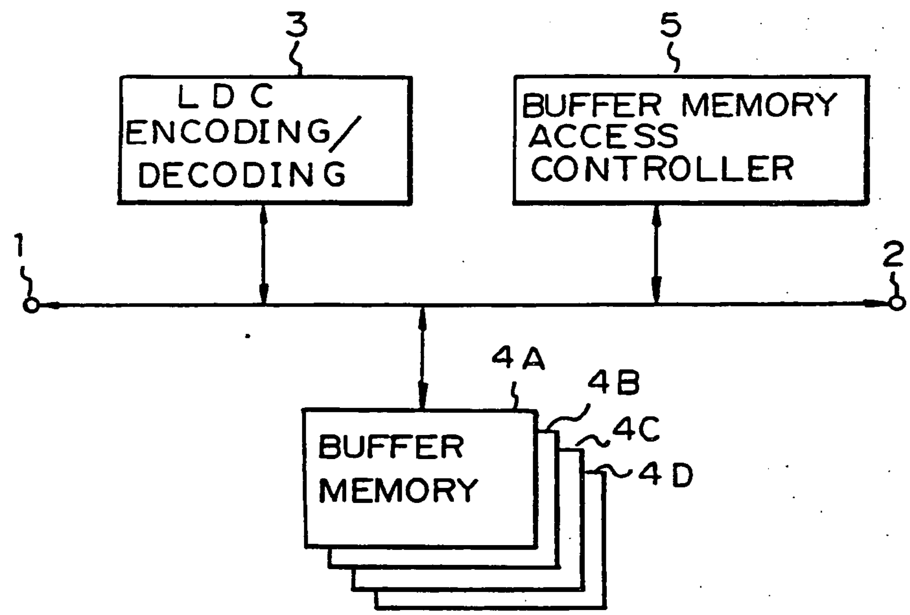

3
LDC
ENCODING/
DECODING
5
BUFFER MEMORY
ACCESS
CONTROLLER
1
2
4A
4B
4C
4D
BUFFER
MEMORY

Fig. 2

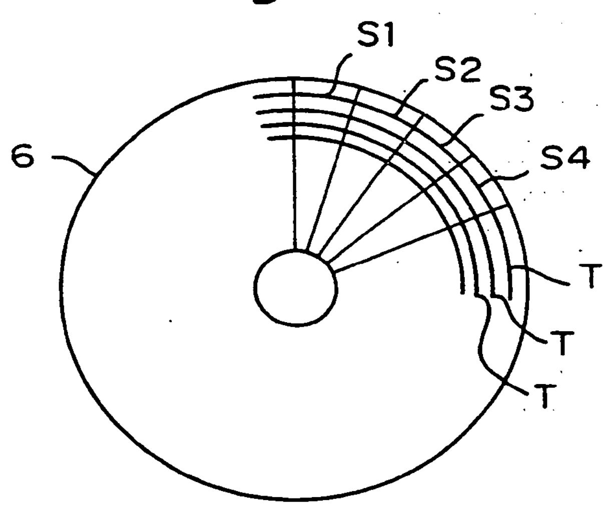

S1
S2
S3
S4
6
T
T
T

Fig. 3

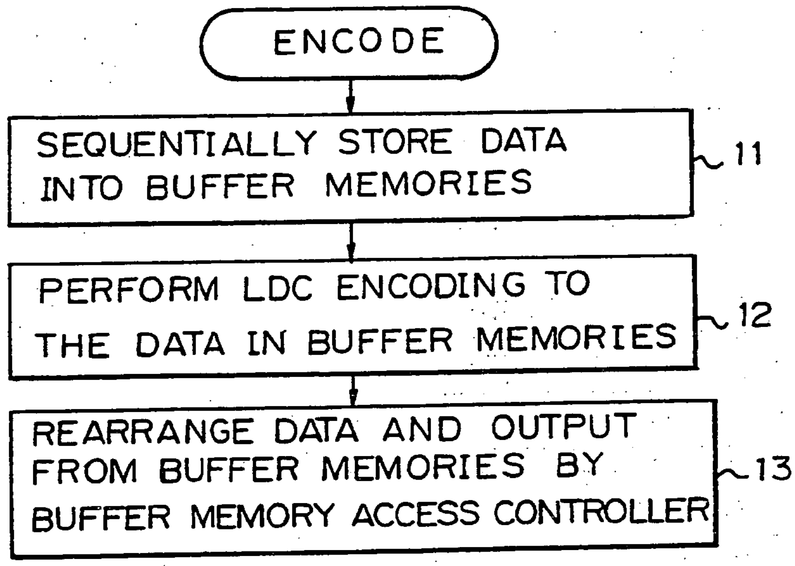

ENCODE
SEQUENTIALLY STORE DATA INTO BUFFER MEMORIES
11
PERFORM LDC ENCODING TO THE DATA IN BUFFER MEMORIES
12
REARRANGE DATA AND OUTPUT FROM BUFFER MEMORIES BY BUFFER MEMORY ACCESS CONTROLLER
13

Fig. 8

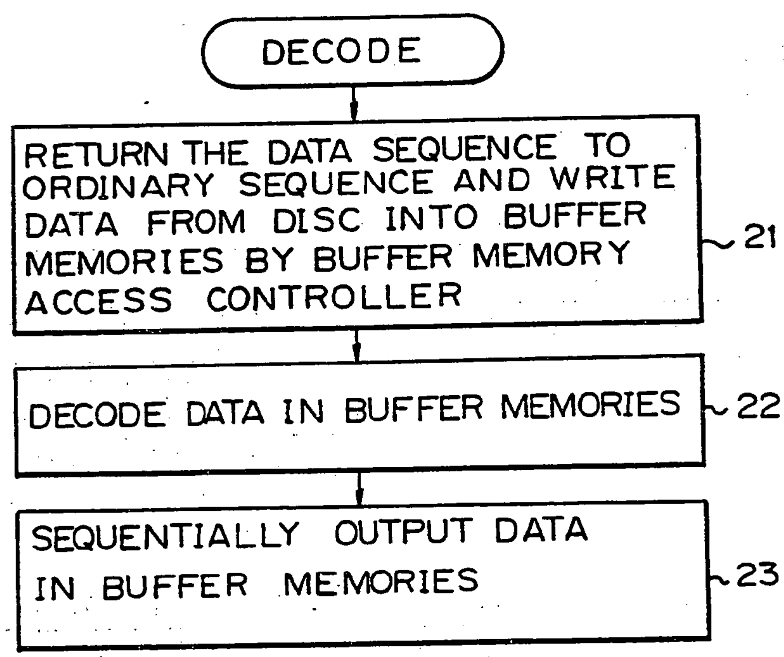

DECODE
RETURN THE DATA SEQUENCE TO ORDINARY SEQUENCE AND WRITE DATA FROM DISC INTO BUFFER MEMORIES BY BUFFER MEMORY ACCESS CONTROLLER
21
DECODE DATA IN BUFFER MEMORIES
22
SEQUENTIALLY OUTPUT DATA IN BUFFER MEMORIES
23

Fig. 4A

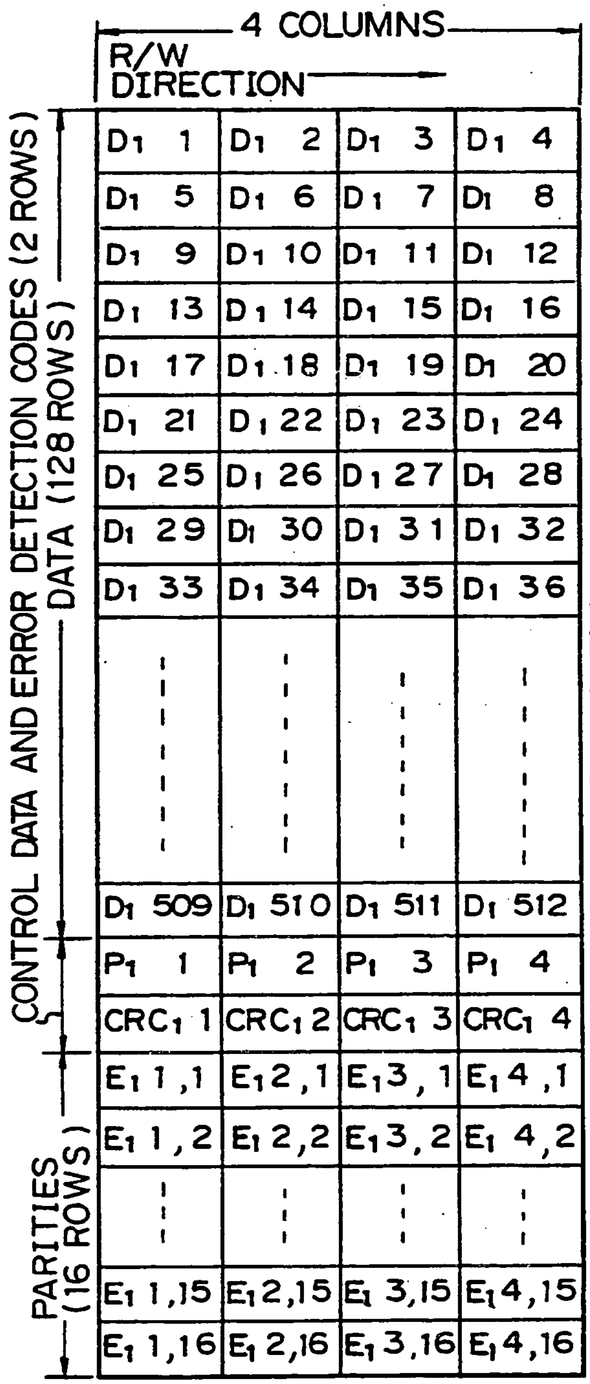

4 COLUMNS
R/W DIRECTION
CONTROL DATA AND ERROR DETECTION CODES (2 ROWS)
DATA (128 ROWS)
PARITIES (16 ROWS)
D1 1 | D1 2 | D1 3 | D1 4
D1 5 | D1 6 | D1 7 | D1 8
D1 9 | D1 10 | D1 11 | D1 12
D1 13 | D1 14 | D1 15 | D1 16
D1 17 | D1 18 | D1 19 | D1 20
D1 21 | D1 22 | D1 23 | D1 24
D1 25 | D1 26 | D1 27 | D1 28
D1 29 | D1 30 | D1 31 | D1 32
D1 33 | D1 34 | D1 35 | D1 36
D1 509 | D1 510 | D1 511 | D1 512
P1 1 | P1 2 | P1 3 | P1 4
CRC1 1 | CRC1 2 | CRC1 3 | CRC1 4
E1 1,1 | E1 2,1 | E1 3,1 | E1 4,1
E1 1,2 | E1 2,2 | E1 3,2 | E1 4,2
E1 1,15 | E1 2,15 | E1 3,15 | E1 4,15
E1 1,16 | E1 2,16 | E1 3,16 | E1 4,16

Fig. 4B

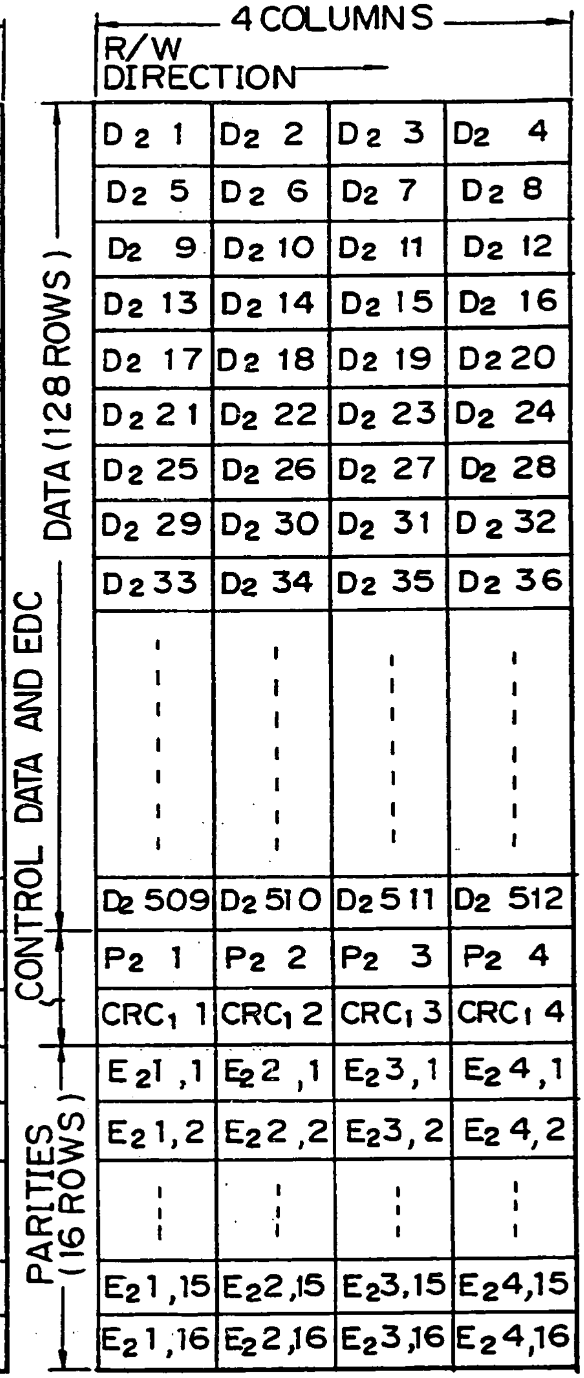

4 COLUMNS
R/W DIRECTION
DATA (128 ROWS)
CONTROL DATA AND EDC
PARITIES (16 ROWS)
D2 1 | D2 2 | D2 3 | D2 4
D2 5 | D2 6 | D2 7 | D2 8
D2 9 | D2 10 | D2 11 | D2 12
D2 13 | D2 14 | D2 15 | D2 16
D2 17 | D2 18 | D2 19 | D2 20
D2 21 | D2 22 | D2 23 | D2 24
D2 25 | D2 26 | D2 27 | D2 28
D2 29 | D2 30 | D2 31 | D2 32
D2 33 | D2 34 | D2 35 | D2 36
D2 509 | D2 510 | D2 511 | D2 512
P2 1 | P2 2 | P2 3 | P2 4
CRC1 1 | CRC1 2 | CRC1 3 | CRC1 4
E2 1,1 | E2 2,1 | E2 3,1 | E2 4,1
E2 1,2 | E2 2,2 | E2 3,2 | E2 4,2
E2 1,15 | E2 2,15 | E2 3,15 | E2 4,15
E2 1,16 | E2 2,16 | E2 3,16 | E2 4,16

Fig. 4C

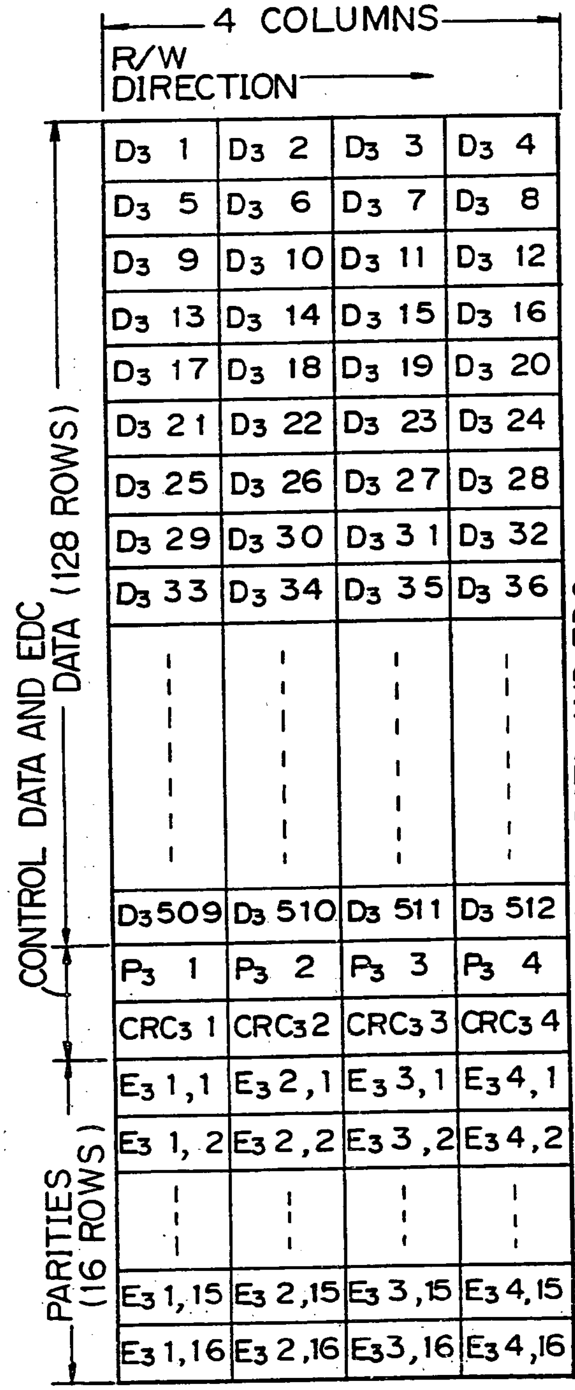

4 COLUMNS
R/W DIRECTION
CONTROL DATA AND EDC DATA (128 ROWS)
PARITIES (16 ROWS)
D3 1 | D3 2 | D3 3 | D3 4
D3 5 | D3 6 | D3 7 | D3 8
D3 9 | D3 10 | D3 11 | D3 12
D3 13 | D3 14 | D3 15 | D3 16
D3 17 | D3 18 | D3 19 | D3 20
D3 21 | D3 22 | D3 23 | D3 24
D3 25 | D3 26 | D3 27 | D3 28
D3 29 | D3 30 | D3 31 | D3 32
D3 33 | D3 34 | D3 35 | D3 36
D3 509 | D3 510 | D3 511 | D3 512
P3 1 | P3 2 | P3 3 | P3 4
CRC3 1 | CRC3 2 | CRC3 3 | CRC3 4
E3 1,1 | E3 2,1 | E3 3,1 | E3 4,1
E3 1,2 | E3 2,2 | E3 3,2 | E3 4,2
E3 1,15 | E3 2,15 | E3 3,15 | E3 4,15
E3 1,16 | E3 2,16 | E3 3,16 | E3 4,16

Fig. 4D

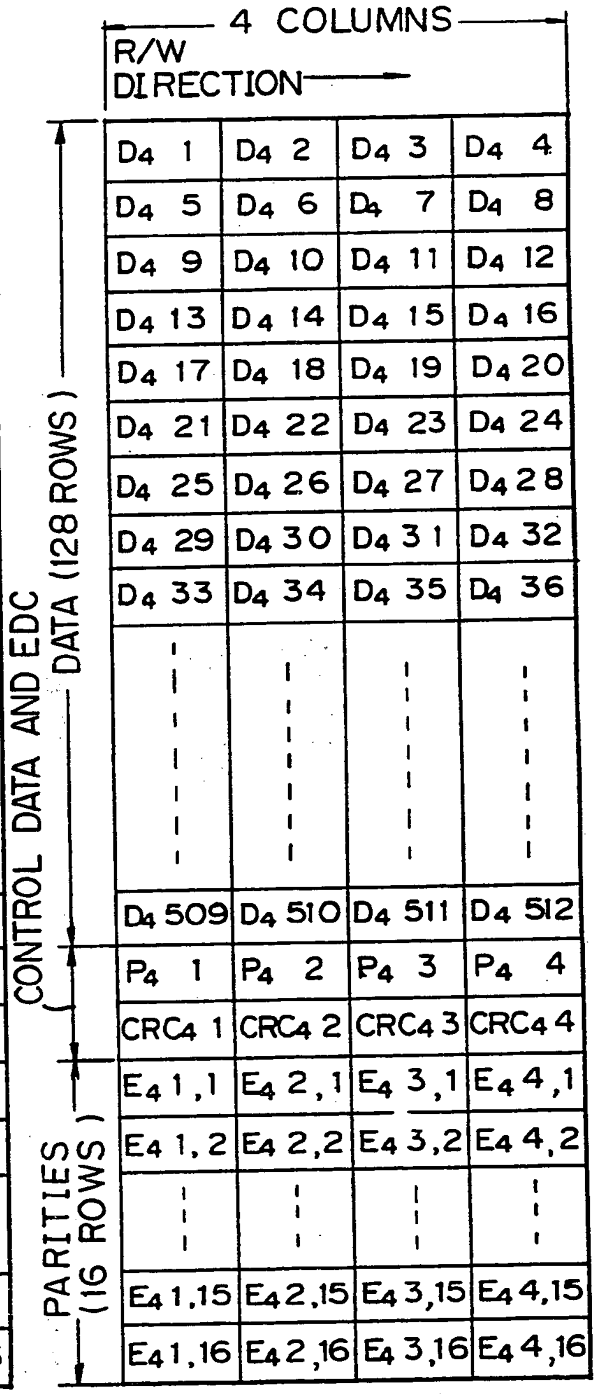

4 COLUMNS
R/W DIRECTION
CONTROL DATA AND EDC DATA (128 ROWS)
PARITIES (16 ROWS)
D4 1 | D4 2 | D4 3 | D4 4
D4 5 | D4 6 | D4 7 | D4 8
D4 9 | D4 10 | D4 11 | D4 12
D4 13 | D4 14 | D4 15 | D4 16
D4 17 | D4 18 | D4 19 | D4 20
D4 21 | D4 22 | D4 23 | D4 24
D4 25 | D4 26 | D4 27 | D4 28
D4 29 | D4 30 | D4 31 | D4 32
D4 33 | D4 34 | D4 35 | D4 36
D4 509 | D4 510 | D4 511 | D4 512
P4 1 | P4 2 | P4 3 | P4 4
CRC4 1 | CRC4 2 | CRC4 3 | CRC4 4
E4 1,1 | E4 2,1 | E4 3,1 | E4 4,1
E4 1,2 | E4 2,2 | E4 3,2 | E4 4,2
E4 1,15 | E4 2,15 | E4 3,15 | E4 4,15
E4 1,16 | E4 2,16 | E4 3,16 | E4 4,16

Fig. 5A

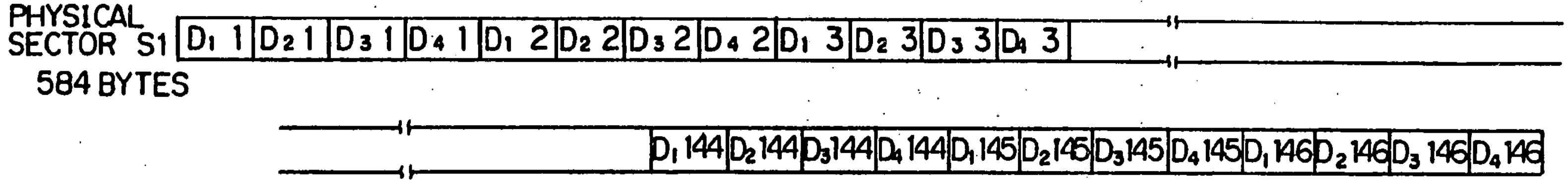


Fig. 5B

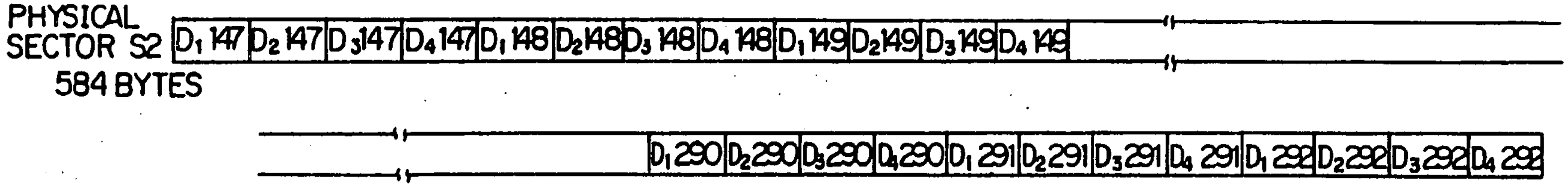


Fig. 5C

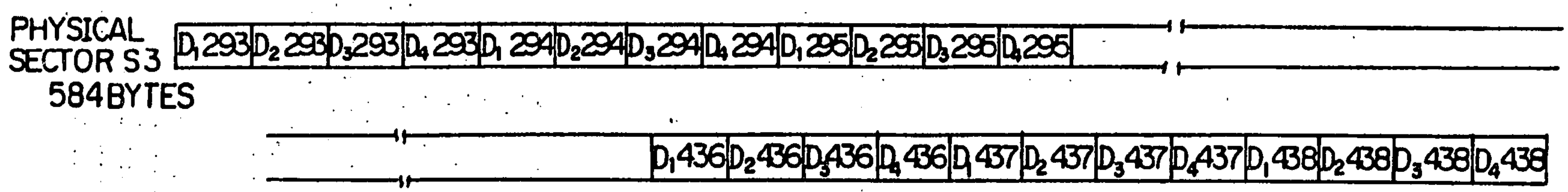
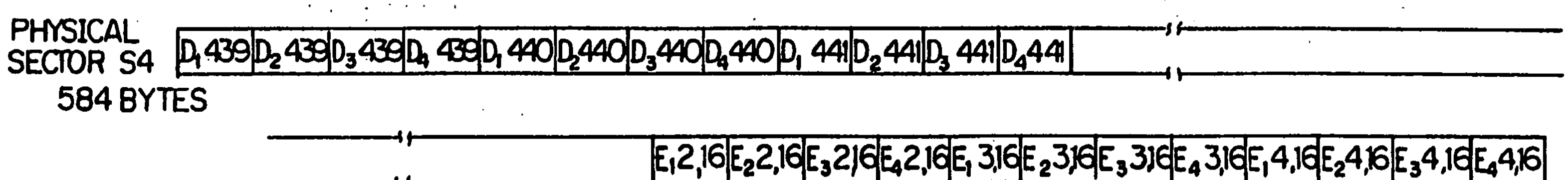


Fig. 5D



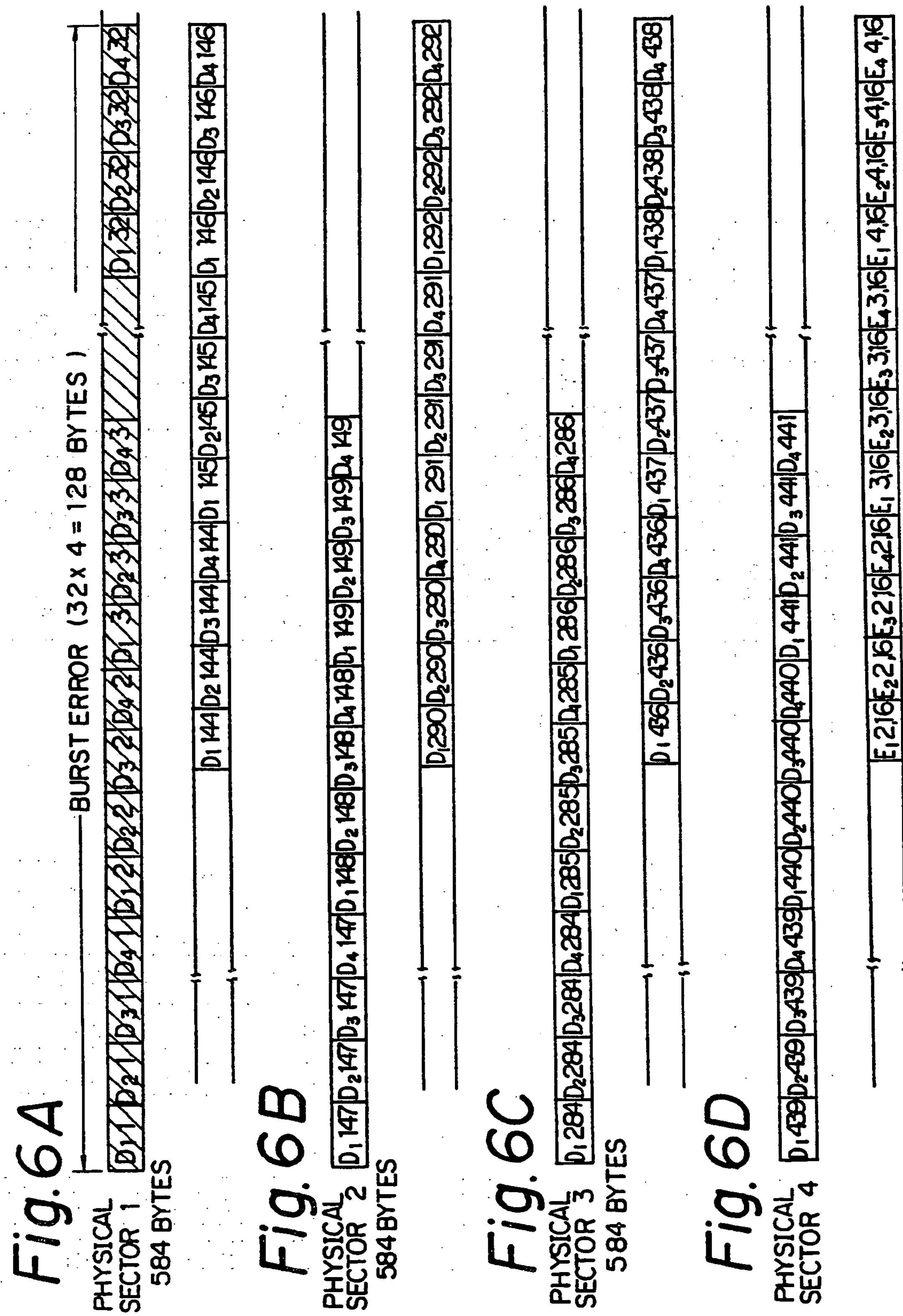


Fig. 6A

Fig. 6B

Fig. 6C

Fig. 6D

Fig. 7A

D_1 1	D_1 2	D_1 3	D_1 4
D_1 5	D_1 6	D_1 7	D_1 8
D_1 9	D_1 10	D_1 11	D_1 12
D_1 13	D_1 14	D_1 15	D_1 16
D_1 17	D_1 18	D_1 19	D_1 20
D_1 21	D_1 22	D_1 23	D_1 24
D_1 25	D_1 26	D_1 27	D_1 28
D_1 29	D_1 30	D_1 31	D_1 32
D_1 33	D_1 34	D_1 35	D_1 36
⋮	⋮	⋮	⋮
D_1 509	D_1 510	D_1 511	D_1 512
P_1 1	P_1 2	P_1 3	P_1 4
CRC_1 1	CRC_1 2	CRC_1 3	CRC_1 4
E_1 1,1	E_1 2,1	E_1 3,1	E_1 4,1
E_1 1,2	E_1 2,2	E_1 3,2	E_1 4,2
⋮	⋮	⋮	⋮
E_1 1,15	E_1 2,15	E_1 3,15	E_1 4,15
E_1 1,16	E_1 2,16	E_1 3,16	E_1 4,16

Fig. 7B

D_2 1	D_2 2	D_2 3	D_2 4
D_2 5	D_2 6	D_2 7	D_2 8
D_2 9	D_2 10	D_2 11	D_2 12
D_2 13	D_2 14	D_2 15	D_2 16
D_2 17	D_2 18	D_2 19	D_2 20
D_2 21	D_2 22	D_2 23	D_2 24
D_2 25	D_2 26	D_2 27	D_2 28
D_2 29	D_2 30	D_2 31	D_2 32
D_2 33	D_2 34	D_2 35	D_2 36
⋮	⋮	⋮	⋮
D_2 509	D_2 510	D_2 511	D_2 512
P_2 1	P_2 2	P_2 3	P_2 4
CRC_1 1	CRC_1 2	CRC_1 3	CRC_1 4
E_2 1,1	E_2 2,1	E_2 3,1	E_2 4,1
E_2 1,2	E_2 2,2	E_2 3,2	E_2 4,2
⋮	⋮	⋮	⋮
E_2 1,15	E_2 2,15	E_2 3,15	E/
E_2 1,16	E_2 2,16	E_2 3,16	E_2 4,16

Fig. 7C

D_3 1	D_3 2	D_3 3	D_3 4
D_3 5	D_3 6	D_3 7	D_3 8
D_3 9	D_3 10	D_3 11	D_3 12
D_3 13	D_3 14	D_3 15	D_3 16
D_3 17	D_3 18	D_3 19	D_3 20
D_3 21	D_3 22	D_3 23	D_3 24
D_3 25	D_3 26	D_3 27	D_3 28
D_3 29	D_3 30	D_3 31	D_3 32
D_3 33	D_3 34	D_3 35	D_3 36
⋮	⋮	⋮	⋮
D_3 509	D_3 510	D_3 511	D_3 512
P_3 1	P_3 2	P_3 3	P_3 4
CRC_3 1	CRC_3 2	CRC_3 3	CRC_3 4
E_3 1,1	E_3 2,1	E_3 3,1	E_3 4,1
E_3 1,2	E_3 2,2	E_3 3,2	E_3 4,2
⋮	⋮	⋮	⋮
E_3 1,15	E_3 2,15	E_3 3,15	E_3 4,15
E_3 1,16	E_3 2,16	E_3 3,16	E_3 4,16

Fig. 7D

D_4 1	D_4 2	D_4 3	D_4 4
D_4 5	D_4 6	D_4 7	D_4 8
D_4 9	D_4 10	D_4 11	D_4 12
D_4 13	D_4 14	D_4 15	D_4 16
D_4 17	D_4 18	D_4 19	D_4 20
D_4 21	D_4 22	D_4 23	D_4 24
D_4 25	D_4 26	D_4 27	D_4 28
D_4 29	D_4 30	D_4 31	D_4 32
D_4 33	D_4 34	D_4 35	D_4 36
⋮	⋮	⋮	⋮
D_4 509	D_4 510	D_4 511	D_4 512
P_4 1	P_4 2	P_4 3	P_4 4
CRC_4 1	CRC_4 2	CRC_4 3	CRC_4 4
E_4 1,1	E_4 2,1	E_4 3,1	E_4 4,1
E_4 1,2	E_4 2,2	E_4 3,2	E_4 4,2
⋮	⋮	⋮	⋮
E_4 1,15	E_4 2,15	E_4 3,15	E_4 4,15
E_4 1,16	E_4 2,16	E_4 3,16	E_4 4,16

Fig. 9A PHYSICAL SECTOR S1

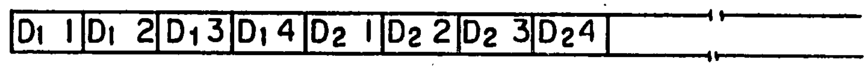


Fig. 9B PHYSICAL SECTOR S2

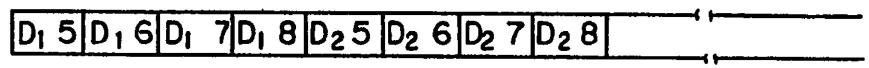


Fig. 9C PHYSICAL SECTOR S3

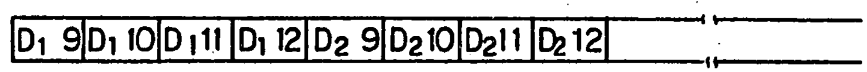
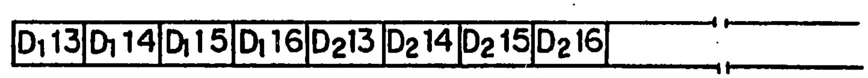


Fig. 9D PHYSICAL SECTOR S4



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(54) Data recording method and apparatus.

(57) A method of and apparatus for recording data onto a disc-shaped recording medium having a sector construction such as an optical disc increases the interleave length of recorded data to cope with burst error or the like by dividing input data into predetermined lengths, respectively two-dimensionally arranging the divided data, generating and adding error correction codes to the two-dimensionally arranged data by a predetermined series to thereby form n encoded blocks; changing the data arrangement among the n encoded blocks; and distributing and recording the changed data to each sector on the disc-shaped recording medium.

Fig. 1

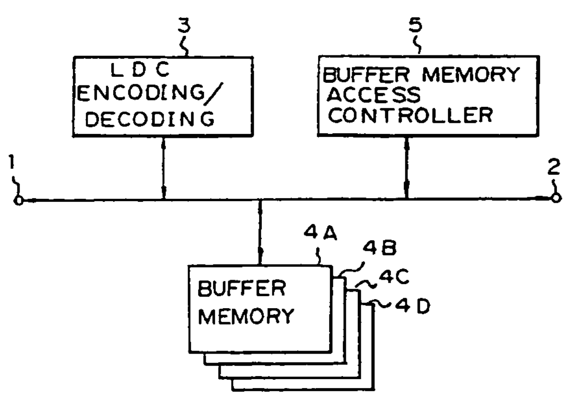
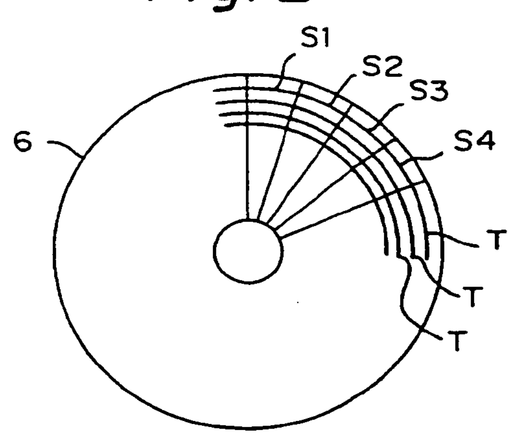


Fig. 2



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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 258 059 (SONY) * claim 1; figure 6 * - - -	1	G 11 B 20/18 G 11 B 20/12
A	EP-A-0 163 481 (SONY) * Page 10, line 18 - page 11, line 9; abstract * - - -	1,4,7	
A	EP-A-0 155 664 (HITACHI) - - - - -		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G 11 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	30 May 91	BRUNET L.M.R.

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